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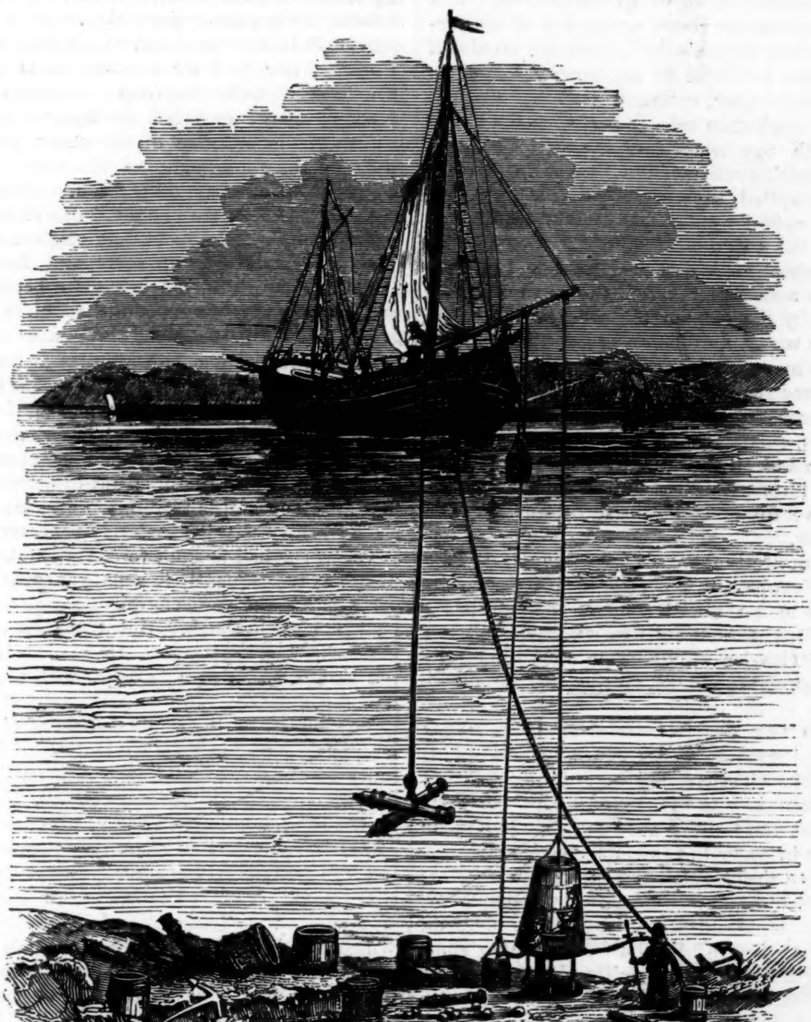
THE DIVING BELL. No. I.



DR. HALLEY'S DIVING-BELL.

It is a remarkable circumstance, that nearly all our most useful inventions are founded upon principles so extremely simple, both in their action and application, as to excite surprise that they should so long have remained unknown. But it generally happens that an inventor magnifies to himself the nature of the object sought to be attained, and creates difficulties where none exist: he constructs extensive and elaborate apparatus, and unmindful of the simplicity of nature's operations, which ought to be his model and his guide, he is not generally content with a simple form of apparatus which he might add to and improve; but he usually constructs one that is intricate in form, and by degrees descends from complexity to simplicity, thus ending where he ought to have begun.

The various forms of diving apparatus, to some of which we alluded in a previous article, were complicated in theory and difficult in practice. The diving-bell in its simplest form is simplicity itself. It is nothing more than a chest or tub, of a conical shape, sufficiently large to contain two or three persons, and being sunk to various depths in water, enables the divers to perform a variety of useful operations.

Although the bell is open at the bottom, it is full of air, so that the water does not enter the bell because the air cannot escape. The reader will understand the whole principle of the diving-bell, by attaching a piece of dry blotting paper to the bottom of a wine-glass: then, inverting the glass, let him lower it steadily into a bucket of water, taking care to hold the glass steadily and to allow the whole rim of the glass to touch the water at the point of immersion. In this way the glass may be lowered to the bottom of the bucket,

and the water will not enter into the glass so as to wet the paper. The reason for this is to be found in a property called *impenetrability* which is common to air as well as to matter generally. By virtue of this property no two bodies can occupy the same place at the same time. What we term an *empty* bottle, is a bottle full of air; and if it be required to fill it with water, the air must first be displaced. If we plunge the bottle under water with its mouth upwards, we hear the air bubbling out exactly as fast as the water enters. The room in which we sit contains air: if a second person enters the room, a quantity of air precisely equal to that person's bulk quits it: so also if we quit the room, a volume of air, precisely equal to the volume of our bodies, enters it.

If the young student in science performs the above experiment with the wine-glass, he will probably observe that a small portion of the interior of the glass near the rim is wetted, thus proving that a portion of the water has actually entered his miniature diving-bell, and that the water enters the glass in proportion to the depth to which he plunges it. This proceeds from another property of the air called *elasticity*, whereby the air, by being subjected to the pressure of the water, diminishes in bulk, and allows a portion of the water to enter the glass; but as soon as the aqueous pressure is removed, the air recovers its former dimensions, and drives the water out of the glass.

Bearing in mind, therefore, these two properties of the air, its impenetrability and its elasticity, the reader will have no difficulty in understanding the following details.

The earliest notice that we find of the use of the diving-bell in Europe, is a description given by Beckmann, of a machine mentioned by John Taisnier who was born in Hainault, in 1509, and held an office in the court of Charles V., whom he attended on his voyage to Africa. He relates that he saw at Toledo, in the presence of the emperor and several thousand spectators, two Greeks let themselves down under water, in a large inverted kettle with a burning light, and rise up again without being wet. It appears that this art was then new to the emperor and the Spaniards, and that the Greeks were requested to make the experiment in order to prove its practicability.

In 1588, when the Spanish Fleet, called the Invincible Armada, sent to besiege England, was dispersed, some of the ships were sunk near the Isle of Mull, on the western coast of Scotland; and these ships were supposed to contain great riches. Many attempts were therefore made to procure part of the lost treasure. In 1665 a person got up some cannon, the sale of which did not realise enough to pay the expenses. On this occasion a rude sort of diving-bell was employed. In 1680, Phipps, a native of America, proposed to procure the treasure from a rich Spanish ship, sunk on the coast of Hispaniola. He laid his plan before Charles the Second, and had a ship and everything necessary to his undertaking furnished to him. He was unsuccessful, and returned to England in great poverty, but with a firm conviction of the possibility of his scheme. A subscription was then raised for him, and in 1687 he made a second attempt, in which he succeeded in getting up treasure to the amount of 200,000*l.* On his return to England, some persons endeavoured to persuade the king to seize both the ship and the cargo, under a pretence that Phipps, when he solicited for his Majesty's permission, had not given accurate information respecting the business. "But the king answered," says Beckman, "with much greatness of mind, that he knew Phipps to be an honest man, and that he and his friends should share the whole among them, had he returned with double the value." The king even conferred upon him the honour of knighthood, to show how much he was satisfied with his conduct. The form of diving-bell used on these occasions by Phipps is not well known, but an old writer describes it as consisting of "a square box bound round with iron, which is furnished with windows, and has a stool affixed to it for the diver.

Up to the year 1678 we find several diving-bells of the simplest form described, varying only in shape, capacity, or modes of supension. It is obvious that a diving-bell, into and from which fresh air cannot be admitted, nor foul air discharged, is restrained in its sphere of usefulness from two causes:—1st. The elasticity of the enclosed air being very great, and subject to the pressure of the water, such air yields to the pressure, and allows the water to enter and occupy the lower part of the bell. So great is this aqueous pressure, that at the depth of 33 feet the air becomes compressed to half its original bulk; so that the bell is half full of water and half full of air. 2nd. The air within the bell soon becomes unfit to support life, and the machine requires to be raised from time to time to procure a fresh supply. In order to breathe freely a person requires at least 400 cubic inches of air per minute: if two persons be in the bell, the consumption of air will equal half a cubic foot per minute. If the bell contain about seventy cubic feet of air, we may suppose the supply capable of holding out for two hours; but in practice it is found that after one hour's respiration of the same enclosed air, a fresh supply is absolutely necessary.

When the bell is sunk to considerable depths, and the air is consequently in a state of great compression, great pain in the ears is frequently experienced, accompanied with headach. But these symptoms disappear with use, especially as the air in the chambers of the ears becomes equally dense with the surrounding medium.

The defects of the original form of diving-bell were long experienced in practice, and called forth the ingenuity of many persons in the construction of an improved apparatus. Among others, the most celebrated improver is Dr. Halley, who, about the year 1715, introduced the great improvement of supplying the bell with fresh air for any length of time, without withdrawing the bell from the water. This was effected by letting down from the vessel, from which the bell was suspended, barrels of fresh air, which discharged their contents into the bell by means of pipes, while the foul air escaped by a small cock fixed in the top of the bell. Another great advantage was, that enough air could be thus introduced into the bell to prevent any water from entering, the air in such case being of course in a condensed state; but the whole cavity of the bell became available for working, and the diver could descend and walk on the bottom of the sea, his feet only being under water, while the rest of his body was in the bell, and consequently surrounded with air.

By reference to our frontispiece, which represents Dr. Halley's diving-bell in actual use, the reader will have no difficulty in comprehending the following details.

Dr. Halley's bell was made of wood: its capacity was about sixty cubic feet: its form, that of a truncated cone. It was coated with lead, and the weight of metal was so distributed that it would sink with the mouth always downwards and horizontal. In the top was fixed a strong but clear glass as a window: below the bell was a stage hanging by three ropes loaded with weights for the sake of steadiness.

The bell was suspended from the mast of a ship by a sprit, well secured to the mast-head, and directed by braces to carry it overboard, clear of the ship's side, and to bring it again within board, as occasion required.

The supply of air to the bell was managed by means of strong barrels, cased with lead, so as to sink when full of air; each barrel held about thirty-six gallons. A bung-hole was fixed in the lower part of each, to let in the water as the enclosed air became condensed during the descent, and to let the water out again when they came up to be filled with air; a hose or pipe in the top of each barrel admitted the air into the bell, the pressure of the water from below forcing the air out of the barrels along the hose into the diving-bell. These two barrels were connected with an endless rope, and were made to ascend and descend alternately; the descending barrel containing air, and the ascending barrel water. In the descent the barrels were directed by lines fastened to the under edge of the bell, which passed through rings on both sides of the leathern hose in each barrel; so that sliding down by these lines, they came readily to the hand of a man who stood on the stage, on purpose to receive them, and to take up the ends of the hose into the bell. Through the hose, as soon as their ends came above the surface of the water in the barrels, all the air was blown with great force into the bell, the water entering at the bung-holes; and as soon as the air of one barrel had been thus received, upon a signal given it was drawn up, and at the same time another descended, and thus an abundant supply of fresh air is maintained within the bell.

Dr. Halley says,—

I myself have been one of five who have been together at the bottom of nine or ten fathoms water, for an hour and a half at a time, without any sort of ill consequence; and I might have continued there as long as I pleased, for anything that appeared to the contrary. Besides, the whole cavity of the bell was kept entirely free from water, so that I sat on a bench which was diametrically placed near the bottom, wholly dressed, with all my clothes on. I only observed that it was necessary to be let down gradually at first, as about twelve feet at a time; and then to stop and drive out the air that entered, by receiving three or four barrels of fresh air before I descended further. But being arrived at the depth designed, I then let out as much of the hot air that had been breathed, as each barrel would replenish with cool, by means of the cock at the top of the bell; through whose aperture, though very small, the air would rush with so much violence as to make the surface of the sea boil, and to cover it with a white foam, notwithstanding the weight of the water over us.

Thus I found that I could do anything that required to be done just under us; and that by taking off the stage, I could, for a space as wide as the circuit of the bell, lay the bottom of the sea so far dry as not to be over shoes thereon. And, by the glass window so much light was transmitted, that when the sea was clear, and especially when the sun shone, I could see perfectly well to write or read, much more to fasten or lay hold of anything under us that was to be taken up. And by the return of the air-barrels I often sent up orders written with an iron pen on small plates of lead, directing how to move us from place to place as occasion required. At other times, when the water was troubled and thick, it would be as dark as night below; but in such cases I have been able to keep a candle burning in the bell as long as I pleased, notwithstanding the great expense of air necessary to maintain flame.

Seeing the success of these attempts, a mind like that of Dr. Halley was sure not to rest satisfied with the capabilities of his diving-bell; he tried to improve it so far as to allow the divers to quit the bell, and walk about on the bottom of the sea, with full freedom to act as occasion required. He constructed caps of lead for the divers to wear, so as to keep the head dry, and receive a constant stream of fresh air from the diving-bell by means of a flexible pipe, one end entering the cap, and the other the diving-bell; this pipe was carried by the diver coiled up on his arm, so as to enable him to lengthen it in proportion to his distance from the bell. Some of these pipes were forty feet long, the size of a half-inch rope. The end of the pipe which opened into the cap, was furnished with a stop-cock, the use of which was to prevent the return of the air in the cap, when the diver stooped down, or got below the surface of the air in the bell, as always happened when the diver got in or out of the bell.

In order to enable the diver to walk about in the water, and to resist any currents he might encounter, it was necessary to diminish his natural buoyancy by attaching weights to his person. The leaden caps were made to weigh between fifty and sixty pounds each; leaden weights were added to the man's girdle, and two clogs of lead were attached to the shoes. Thus it was found, that a man could stand with ease in an ordinary stream, and even move against it. The diver was clothed in thick woollen drawers, and a waistcoat of the same stuff, which becoming full of water would be a little warmed by the heat of the body, and keep off the cold of the surrounding water.

In order to enable the diver to see, the cap near the face was prolonged, and glasses fixed in apertures opposite the eyes. In tolerably smooth and clear water, the diver was enabled to perform a variety of useful offices, with almost as much ease as if he were on land.

This (says Dr. Halley) I take to be an invention applicable to various uses, such as fishing for pearls, diving for coral or sponges, and the like, in far greater depths than has hitherto been thought possible. Also for the fitting and placing of the foundations of moles, bridges, &c., in rocky bottoms, and for the cleaning and scrubbing of ships' bottoms when foul, in calm weather at sea.

We have thus traced the progress of this useful invention up to the time of Dr. Halley; its further progress up to the present day will form the subject of another article.

FRUIT TREES.

It is presumable that the chesnut always grew in Italy, and the cherry in France; but different kinds, on account of their superior excellence arising from cultivation, were imported by the ancient Romans. Wherever their arms extended, they availed themselves of the choice fruits of the conquered countries, and the great generals who brought them to Rome took pride in giving them their own names, as in memory of some great service or pleasure they had done their country; so that not only laws and battles, but several sorts of apples or *mala*, and of pears, were called Manlian and Claudian, Pompeian and Tiberian, and by several other such noble names. Thus, in process of time, the inhabitants of Italy, who formerly lived on acorns, made the whole world tributary to their subsistence, as well as to their glory. Humboldt, in his *Account of New Spain*, says that the *Prunus avium*, or wild cherry, is indigenous in Germany and France, and has existed from the most remote antiquity in their forests, like the robur and the linden tree; while other species of cherry-trees, which are considered as varieties, become permanent, and of which the fruits are more savoury than the *Prunus avium*, have come to those countries through the Romans from Asia Minor, and particularly from the kingdom of Pontus.

Turnips and carrots are considered indigenous roots of France: our cauliflowers came from Cyprus, our artichokes from Sicily, lettuce from Cos, and shallots, or eschallots, from Ascalon. The art of gardening was introduced into England from the Continent about 1509, prior to which, most of the present produce of kitchen gardens was imported from the Netherlands.

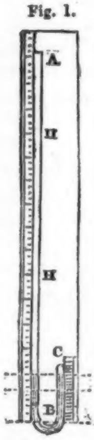
RECREATIONS IN NATURAL PHILOSOPHY.
No. XIII.

ON THE ELASTICITY OF THE AIR (*continued*).

A STEEL spring can be said to be elastic, only when it is bent, because it loses its tension, or elasticity, as soon as it is allowed to repose in an unconstrained position: but the air is always in a state of tension, since it is constantly endeavouring to occupy a larger space: hence a given volume or bulk of air depends upon the pressure to which it is subjected, at any given temperature: or, to state the law a little more precisely, *volumes of gas are in the inverse ratio of the pressures which they sustain.*

This law can be demonstrated by a very simple apparatus shown in fig. 1. It consists of a long glass tube, curved near the end, so as to form a shorter branch, B C, parallel with the first, B A. This shorter branch is closed at the end, but the longer branch remains open, in order that the contents of the tube may be exposed to atmospheric pressure. A small quantity of mercury is poured into the tube, and inclined, so as to remove a portion of air from the short branch, so that the metal may stand at the same level in both branches. When such is the case, the air in the short branch is subject to atmospheric pressure only. If now, by any means, the air in B C is made to occupy only the half, the third, or the fourth, of the length B C, we then know that the air is reduced in volume, to one-half, one-third, or one-fourth of its original volume, because the tube is cylindrical. Now when we say that the air in B C is under atmospheric pressure, we mean that the air is in such a state of density, that its pressure is equal to about fourteen and a half pounds on every superficial square inch; and, as such, is capable of supporting a barometrical column of 30 inches of mercury.

Fig. 1.



If the barometer stand at 30 inches, and at that time we enclose a portion of the atmospheric air, or any gas, in a glass tube, such as A B, fig. 1, it is obvious that we take a portion of air capable of maintaining the barometric column at that elevation. If the barometer indicate 29 inches, the air is obviously less dense than at 30 inches. If it indicate 31 inches, the density is proportionally increased. Now the *mean* height of the barometer at the level of the sea is 30 inches, which is equal to a pressure of *one atmosphere*, or fourteen and a half pounds on the square inch. Supposing now that we pour into the tube at A a portion of mercury, equal to 30 inches, and that the level of the mercury in the longer branch is now at H, what is the consequence? we no longer find the air in the tube B C occupying the space from the lowest dotted line up to C, but it has diminished one-half, and its level corresponds with that of the middle dotted line. The air is now under a pressure of two atmospheres; viz., 30 inches of mercury, equal to one atmosphere, and the atmospheric pressure on the summit of the column, equal to another atmosphere. By continuing to add mercury to the long branch we shall find that a pressure of three atmospheres is necessary to reduce a volume of air to one-third of its original volume; four atmospheres to reduce it to one-fourth, and so on.

Hence it will be seen, that the proportion in which the volume of air is diminished, is precisely that in which its power of resistance is increased. If the volume of air be diminished one-half, its resisting power is doubled; if diminished to one-third, it is tripled; and so on, up to sixty atmospheres. Beyond this limit we cannot be quite sure of the application of the law, although M. Œrsted has subjected air to a pressure of 110 atmospheres; and such was the resistance of the air, that his apparatus became deranged, and vitiated the results. Many of the gases become liquefied, when subjected to great pressure, and in such state the above law does not of course apply to them.

The tension of a gaseous body contained in a close vessel may be known and regulated by means of a little instrument, shown in fig. 2, consisting of a tube bent twice, and open at both ends. In the middle of the tube a bulb is blown, and a portion of mercury is contained in two of its branches. The action of this instrument, (which is called a *safety-tube*), is as follows:—the lower open end is fixed air-tight into the vessel containing the gas: if the gas be in the same state of tension as the surrounding air, the level of the mercury will not be disturbed: if the gas be more condensed than the exterior air, it will press upon the surface of the mercury in the middle branch, and force it to a height in the outer branch depending upon the difference between the elasticity of the enclosed and external air. If the tension of the enclosed air be less than that of the atmosphere, then the latter will prevail, and force the mercury up towards the bulb: if this difference be very great, the whole of the mercury will be forced into the bulb, and a portion of atmospheric air will enter and pass down into the vessel, to compensate for the difference in the respective tensions of the two airs: the mercury will then fall down, and occupy a portion nearly the same as that shown in the figure.

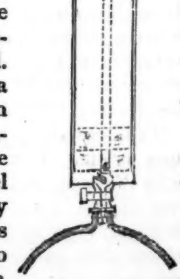
Fig. 2.

This little instrument is called by the French a *Manometer*. Its uses are various and important. It has been frequently employed in researches on animal and vegetable bodies: the central bulb has been so constructed as to contain an animal or a vegetable, and the presence of either body has materially altered the state of tension of the enclosed air, as indicated by the variation in the level of the mercury. In chemical operations, explosions and absorptions are frequently prevented by this safety-tube. In gas-works, where a certain pressure is necessary to distribute the gas through the pipes which supply a whole town, this little tube indicates the state of pressure employed, and points out when a variation is necessary. In the smelting of metals this tube indicates the state of tension of the air employed to excite the blast-furnace, &c.

That apparatus which is employed to diminish the tension of the air is called an *air-pump* or an *exhausting syringe*.

Similar to the latter, but contrary in its action, is the *condensing syringe*, shown in fig. 3. The vessel in which air is to be condensed, must be of metal, and excessively strong, on account of the increasing resistance of air in proportion to its density. This vessel is shown in part in the figure: it is furnished with a stop-cock, to which the syringe is screwed. This syringe is nothing more than a brass cylinder, containing a piston working air-tight, with a valve opening downwards (as at *a*), fixed at the bottom of the syringe. The vessel being full of air of the same density as the external air, the syringe is screwed on, and the piston moved to the top of the cylinder. Air from

Fig. 3.



without will enter at the aperture *t*, and fill the cylinder from below the piston downwards. On pressing down the piston, the air will be condensed and the valve forced open; and the air, having no means of escape, is forcibly driven into the vessel already full of air, and now containing an additional portion. As the valve *a* opens downwards, the attempt of the air to escape operates in keeping the valve more firmly closed. The piston is now drawn up so as to clear the hole *t*, more air rushes in to fill the cylinder, the piston is again depressed; the valve opens, and a second additional quantity of air is forced into the vessel. By a repetition of these processes, the air in the vessel may be brought to an enormous and even dangerous degree of tension. A few years ago, a gentleman, well known in the scientific world, met with his death by the bursting of a vessel containing condensed air. Before the syringe is removed, the stop-cock is, of course, closed.

We will conclude this article with an account of a very ingenious scientific toy, shown in fig. 4.

A tall cylindrical glass jar is nearly filled with water: little hollow glass figures of men, in various attitudes, and bearing each a glass bulb on its head, are filled with water, leaving the glass bulb full, or nearly full, of air. Each figure has a small hole in it, situated near the heel, through which water may pass, in or out. To fill them with water, they are plunged under the surface of that liquid; a fine capillary tube is passed into the hole, the air is sucked out, and the water enters: enough air is left in the bulb that each figure shall be a little lighter than its own bulk of water. The figures are now placed in the glass of water, the mouth of which is then to be covered, air-tight, with a sheet of India rubber. On pressing upon this cover the figures are instantly set into motion, descending in the water, and rising again when the pressure ceases. By modifying the pressure they can be made to sink, to rise, to remain still, or to dance. The jar is sometimes inverted, and the cover passed through a hole made in the table, and the exhibition produces all the motions by pressing, with his foot, a lever connected with the cover; and the figures then appear to the astonished spectators to obey the word of command of their master.

Fig. 4.

But the young student will not be so deceived: he will already have perceived that the varying elasticity of the air produces all these motions. The pressure on the cover of the jar first condenses the air immediately below: this condensation produces a similar effect on the water throughout its whole extent, (for fluids exert their pressure in all directions, and as a whole,) and thus the air in the glass bulbs which the little men wear, is compressed into a smaller space, more water entering each figure through the aperture: each figure therefore becomes heavy enough to sink. When the pressure ceases, the air in the bulb expands, in virtue of its elasticity, forces out the additional portion of water that had entered the figure while the pressure continued, and thus, becoming again lighter than its own bulk of water, it ascends.

If the specific gravity of each figure be very nearly equal to that of water, the figures, having once sunk to the bottom, will not rise again, because the pressure of the liquid column from above prevents the air from regaining its former dimensions, and the figures thus remain permanently heavier than their own bulk of water, and cannot ascend.

So also, if we place several flat leaden weights upon the cover, so as to sink the figures to the bottom; and if, on the removal of all the weights, the figures rise, we shall find than a less weight is necessary to retain them at the bottom of the jar, than was originally employed to sink them. For example: we place five one pound weights upon the cover, and these are just sufficient to sink the figures: we take off one weight, and the figures do not rise: we take off another, and still they do not rise; although they show indications of doing so, by a slight motion: we take off a third weight, and the figures rise rapidly. Hence, although five pound weights were necessary to sink the figures, yet three pounds are sufficient to retain them sunk; the remaining two pounds being made up by the pressure of the liquid column above them.

If the little figures be delicately made, and poised in water, so that a slight increase of pressure is sufficient to sink them, the varying pressure of the air will cause them to occupy different positions in the jar; and thus, this toy acts as a barometer

This beautiful little toy is instructive: if the student understands completely its action, he is in possession of a good deal of knowledge belonging to the branches of science, called Pneumatics and Hydrostatics. This toy proves,—1st, that air is *material*, because it acts as a mechanical force, communicating the pressure it receives to the liquid column;—2nd, That air is *compressible*, because the air in the bulb can be made to occupy a smaller space;—3rd, That air is *elastic*, because when the pressure is removed, it returns to its former volume;—4th, That air is *light*, but, nevertheless, has weight; it is light, because, although the figure is full of water, the air in the bulb buoys it up;—5th, That *fluid pressure* is exerted in all directions; for we first compress the air under the cover, that pressure is transmitted to the water, and that again to the air in the bulb;—6th, That *pressure* among liquids *is as to the depth*; for although it took five pounds to sink the figures, three pounds were sufficient to retain them sunk, the fluid pressure supplying the remainder;—7th, That *fluids support solids*, according to the difference between the weight of the solid and that of the bulk of water displaced. Now as every solid plunged into water displaces its own bulk of that fluid, such body will float if it be lighter than its own bulk of water; it will sink if it be heavier, and will remain suspended in any part of the liquid if its weight remains the same.

It will be our duty as we proceed, to call the attention of the young student to many other toys, from which we hope to extract a great deal of scientific knowledge.

EXAMINING carefully the internal structure of the perfect animal and the perfect vegetable, and observing minutely the manner in which both are fed and nourished, we find a very striking resemblance between the organs of digestion, circulation, and respiration of both; for they display the most remarkable property of organized beings, as distinguishing them from dead inorganized matter,—that of internal nutrition and growth. They receive into themselves foreign and dead substances, and change them within their own organs to different substances; throw off from themselves such as are not needed for the support of the being, and expose the rest to the air, or breathe upon it, and then from this select one portion for supplying the waste of the body, another for the growth, forming out of it all the varying substances which enter into the man or the tree.

VOCAL ORGANS OF BIRDS.—In man, and most of the warm-blooded animals, the larynx, or vocal box, forms a protuberance in the front of the throat; but in birds, the same organ is placed at the bottom of the neck, instead of the top.

MATERIALS FOR THE TOILETTE. III.

A LOOKING-GLASS.

IF we had a looking-glass for the mind, as faithful, as uniform, and as spotless, as that which reflects the face, should we not be the better for it? Should we not discover the weaknesses, the bad propensities, the deformities of our minds? Surely such would be the case; and as surely should we be drawn to ponder on our faults, and endeavour to eradicate them.

But the inquiry into the best mode of obtaining a *mental* looking-glass is too extensive and serious a subject to be mixed up with our present inquiry, which relates to a reflector of another kind.

How often have we, when children, looked at the back of a glass to endeavour to discover where the person is, whom we think we see on viewing the front. How frequently do we see a dog or a cat make an angry snap at the impertinent opponent whom he sees in the glass? These are proofs of the fidelity with which the reflection is rendered by the glass; and form, as the mind expands towards maturity, a most admirable subject for study. We may suppose a boy, eager to discover the causes of things, whenever an opportunity offers for so doing, to take a dressing-glass, and to remove the board from the back in order to discover the secret of its formation. He sees the hinder surface of the glass covered with a silver-looking substance, with a slight lustre, but no power of reflecting the features of a person who looks at it.

Influenced by a feeling similar to that which actuated a celebrated personage well known in every nursery, who performed a certain operation on a pair of bellows for a certain purpose—he scrapes off some of the metallic substance at the back of the glass, and then finds that he has reduced the latter to precisely the same state as window-glass,—that is, he can see *through* it, but cannot see his face reflected *from* it.

He then feels himself justified in supposing that the source of the reflected image of his face must be in the metal itself, and not in the glass to which it is attached. He hears people call the dressing-glass a *silvered* glass, and therefore supposes that a coating of silver is laid on the glass. He may then ask, "If it is the silver which reflects, why do they not use a sheet of silver at once?—What use is the glass?" The young querist, if he asks any one who knows anything about it, now learns that the metal is *not* silver, but *quicksilver*, of which the scientific name is mercury; that mercury is, in our climate, always in a fluid state, the only metal which is so;—that a fluid could not be used as a looking-glass or mirror, for obvious reasons;—that the sheet of glass is merely a substance used for attaching the mercury to; and that a transparent substance such as glass, is employed for the purpose, in order that nothing should impede the passage of the light to and from the mercury,—transparency being merely that property in a body which allows light to pass through it.

These are the facts which the young inquirer learns, and few things are more attractive and remarkable than these. If he extend his inquiries still further, he will find that a reflection of his face will be afforded by the transparent piece of glass, without the aid of any mercury behind it, although that reflection is too faint to answer the purpose for which a dressing-glass is employed. Let him take a piece of transparent plate-glass, or even window-glass, and hold it so that light can fall on his face but not on the glass, he will see a faint image of his face reflected from it.

When he extends his studies into the beautiful science of optics, he will find that all these things are in perfect accordance with the laws which have been found to prevail in that science. Every visible body, whether it be a luminous object, such as the sun, or a candle; or an illuminated object, such as a sheet of paper, a green field, the wall of a room, or other non-luminous body, sends forth rays of light in every direction; which rays preserve a straight line in their course, so long as they meet with no obstacle. but if they meet with an obstruction, they either pass through the obstructive body, or are reflected from it, or are stopped or stifled by it.

Now in the case of a looking-glass, the philosophy of the matter is as follows:—We always, when "looking at ourselves in the glass," stand where the light falls on the face. This light is reflected from the face, and proceeds towards the looking-glass, as well as towards other parts of the room. When it meets with the surface of the glass, a solid obstacle is opposed to its progress; but it so happens that glass is a substance which, though solid, permits light to pass through. When the light reaches the hinder surface of the glass, and penetrates through it, it then meets with a substance which refuses a passage to it. the mercury is opaque, that is, it has not the property of allowing light to pass through it. What is now the result? What becomes of the light? A small portion of it is absorbed or stifled (for philosophers do not yet know which is the better term to apply to it) by the substance of the mercury; and the rest is reflected, or driven back, through the glass again, and then enters the eye of the spectator.

Now, although this has taken us several words to describe, all of this routine takes place in an incredibly short time. When we stand before the glass and look into it, we see the image of the face instantly, and we are not in the slightest degree aware that any particular process has been gone through before the image is presented to us. In fact, however, the whole of the circumstances to which we have lately alluded, occur *after* we place ourselves in front of the glass, and *before* the rays of light, or the image, reach the eye, and yet these two events seem absolutely simultaneous. If a lady should say, "I think I am pale to day, I will look;" she does not expect to wait standing before the glass until certain optical phenomena have been completed, before she can see whether she is pale or not; she expects to ascertain the fact at once, the instant she looks in the glass; and turns away from her "facial monitor" pleased or displeased, confirmed or shaken in her opinion respecting her paleness,—but without giving a thought of the optical means by which the reflection had been afforded, and still less that the reflection was really *not* afforded until certain events had transpired.

Yet it is most true that *time* does elapse before a reflection of the face is afforded by the glass. The rays of light proceeding from the lips of the spectator, for instance, traverse the space intervening between him and the glass, enter the glass, traverse its thickness, are reflected from the mercury at the back, traverse the thickness of the glass again in the opposite direction, emerge from its front surface, pass through the space between the glass and the observer, and enter into his eye, and he then says "he sees his own lips in the glass." Now all this is done in a due and regular order, one process following another, and *time* must indisputably be consumed in so doing; but when we come to speak of millionth parts of a second of time, it is sufficiently explained why we cannot perceive that a time elapses between the presentation of the face before a looking-glass and the

reflection of an image of the face. The light of the sun has to perform a journey of nearly one hundred millions of miles before we are blessed with a sight of him; and how long does the reader think the rays of light are traversing this distance?—Eight minutes and a quarter!—at the rate of two hundred thousand miles per second!—nearly as far as from the earth to the moon in one second! We need not, therefore, charge ourselves with much inaccuracy, if we say, as every one thinks, that the reflection of the face takes place at the very instant that we look in the glass.

We have said, that when the light passes through the glass, it is reflected from the mercury which is behind, and this is certainly the reflection to which our attention is directed when we look in the glass. But there are two other reflections going on at the same time, but so slight as to escape notice. When rays of light fall on the front surface of the glass, they do not *all* penetrate it, but some are reflected at that surface. Again, of those which *do* enter the glass, all do not penetrate to the mercury, but some are reflected from the hinder surface of the glass, before they reach the mercury. If we hold a looking-glass in an oblique direction, and place any object, such as a shilling, upon it, we shall see two reflections of the shilling,—a bright one from the mercury and a faint one from the front surface of the glass; and there is also a third, from the hinder surface of the glass, but it is too near that from the mercury to be visible: the more obliquely we view the reflection, the more evident do the fainter ones become.

If we take a piece of window-glass, and blacken the back of it, so as to prevent light from passing through it, we obtain a reflection of the face, which, although altogether inferior to that from a silvered glass, is yet sufficient to show the features. Now it is found that this reflection does not come from the front surface, but from the hinder surface of the glass; or, rather, that it is a combination of the two, but that the hinder is the stronger. When, therefore, we look into a silvered glass, we actually obtain *three* reflections,—one from the front surface, one from the back surface, and one from the mercury, although the last-mentioned is so much the most vivid, that the other two entirely escape our observation.

Who does not remember the wonderful effects of the wonderful mirrors produced by "jet blacking?"—the many cats who have raised big backs at seeing themselves in a polished boot, &c. &c. Now why is it that a boot becomes a mirror after it has received a coating of the "superlative" blacking? Because the pores and irregularities of the leather are filled up with a species of varnish, and reduced to a tolerably level and smooth surface, so that the light which is reflected from the leather approaches in some degree to the regularity of that reflected from a looking-glass. The same is true of a polished tea-tray, and articles of a similar kind. The material of which they are formed is not in itself possessed of such a smooth surface as to afford a reflection of the face; but by covering it with a species of japan, the irregularities are filled up, and a smooth surface obtained. Japans, varnishes, French polishes, and everything of that description, act on this principle.

Now this is the reason why a piece of plate-glass is so valuable as the material to which the mercury is attached. Not only is it as transparent as any solid substance hitherto known, but it possesses a surface so exquisitely smooth, that the manufacturing arts can scarcely produce a parallel instance to it. What we call *ground* glass is glass which has had one side roughened by a species of grinding: nothing has been added to, or subtracted from, the materials of the glass itself; its nature has not been changed, but its surface, by being roughened, prevents light from passing freely through; and if one side of such glass were to be silvered, we should find that it would utterly fail us as a looking-glass; it would afford no image of the face, not even so good as from a piece of blackened glass.

Everybody prefers "plate" glass to "common" glass, as a dressing-glass, because the latter presents the spectator with a reflection anything but like the original. A Grecian nose may become a pug,—an arched eye-brow may become marvellously crooked,—an oval visage may become as squat as that of Sancho Panza. Now this is no fault in the substance of the glass itself; it results merely from the circumstance that the surfaces of the glass are not *flat*. The light passes through the glass as easily as through plate glass, but from the crookedness of the surfaces it is bent and distorted out of its proper directions.

On some occasions the toilette is provided with concave and convex looking-glasses, as well as the usual flat ones. The convex have the property of diminishing the size of the reflected object, and the concave that of magnifying it; whereas, the flat, or plane glasses, yield an image the same size as the original would appear if it were behind the glass, and the glass transparent. The action of the convex and concave mirrors is dependent on certain well-defined laws of optics, but which are rather too intricate to engage our attention here. The light penetrates through the substance of the glass, and is reflected from a coating of mercury on the back.

If a piece of stained glass were used as a looking-glass,—by having a coating of mercury on one side, it would present an image of the face the same as with colourless glass; but it would be tinged with the colour with which the glass is stained: and would not appear so brilliant, because much of the light is absorbed by the glass, or by the material with which it has been stained.

Having thus treated of the philosophy of the *action* of a looking-glass, we must in another article speak of the philosophy of its *manufacture*, and of the source of that remarkable metal, mercury, with which one of its surfaces is coated, and by whose means it is enabled to act as a looking-glass.

LOCUSTS.

MR. MADOX, in his recent travels through Egypt, says,—"April 8th, an immense host of locusts showed itself, during the last three or four days, apparently coming from the east. The number of these insects absolutely obscured the atmosphere, which otherwise was clear and serene; though the vibratory motion of their wings in the brilliant sunshine had a peculiar and rather pleasing effect. They flew heavily, and frequently struck against the houses, and falling on the ground, the fowls and dogs devoured them with much avidity, particularly the latter, who ate them so voraciously that they made themselves sick. These locusts were of the form and size of large grasshoppers, and many alighted on the neighbouring grounds to deposit their eggs upon the verdure. The governor, however, most providentially sent people to collect and destroy them, which was effected by burying them deep in the ground, or by burning them in heaps. I afterwards saw innumerable swarms of these insects floating on the sea, and covering the whole line of coast."

M. ARAGO, the French philosopher, has advanced the opinion, that the climate of France is gradually becoming colder. He supposes the advance of the north polar ice towards the temperate zones, to be the cause. Sir John Barrow advanced a similar notion concerning the climate of England many years ago.

RISE AND PROGRESS OF THE SILK MANUFACTURE.

No. II.

Mulberry-Trees;—the Silk-Worm.

There are different species. It is hardy, of quick growth, and easily naturalized in all climates. The black species has always been cultivated for its fruit in Europe: the white sort comes from India, whence it has been introduced into all the western countries which have attempted the culture of silk. The respective qualities of each species, as connected with the silk-worm, cannot be better pointed out than by observing, that if leaves of the white, next the red, and lastly the black, be given at the same time, to the insect, it will eat first the white, next the red, and lastly the black. The white came originally from China, and would appear to be its most natural food.

It is said that no insect, excepting the silk-worm, will feed on the mulberry-leaf. Other fruit-trees in the same garden were sometimes covered by myriads of insects, while the mulberry tree, surrounded by these ravagers, remained sacred from their depredations.

The silk-worm, or bombyx, is a species of caterpillar, which, like all other insects of the same class, undergoes a variety of changes, during the short period of its life; assuming in each of the three successive transformations, a form wholly dissimilar to that with which it was previously invested. Silk-worms proceed from eggs which are deposited during the summer by a grayish kind of moth. These eggs are of the size of a grain of mustard-seed, of a yellow colour. When first hatched, it appears as a small black worm, about a quarter of an inch long. Its first indication of life is the desire which it evinces for obtaining food, and if not immediately supplied, it will exhibit more power of locomotion than characterizes it at any other period. So small is the desire for change, on the part of these insects, that it may generally be said, their own spontaneous will seldom leads them to travel more than three feet throughout the whole duration of their lives. In about eight days from its being hatched, its head becomes perceptibly larger, and the worm is attacked by its first sickness. This lasts three days, during which time it refuses food, and remains motionless in a kind of lethargy. At the end of the third day from its refusal to eat food, the animal appears much wasted in its bodily frame, a circumstance which materially assists in the painful operation of casting its skin.

The first effort is to break through the skin nearest to the head, which, as it is the smallest there, calls for the greatest exertion; and no sooner is this accomplished, and the two front legs disengaged, than the remainder of the body is quickly drawn forth. This moulting is so complete, that not only is the whole covering of the body cast off, but that of the feet, of the entire skull, and even the jaws, including the teeth. These several parts may be discerned by the unassisted eye, but become very apparent through a magnifying lens of moderate power. In two or three minutes the worm is wholly freed, and again puts on the appearance of health and vigour, feeding with recruited appetite upon its leafy banquet, and continuing to feed during five days. At this time its length will increase to half an inch, and then it is attacked with its second sickness, followed by a second moulting, similar to the first. Its appetite then returns, and is indulged during other five days. Increasing to three-quarters of an inch, it then undergoes its third sickness and moulting. These being past in all respects like the former, and five more days of feeding having followed, it is seized with its fourth sickness, and casts its skin for the last time in the caterpillar state.

The worm is now one and a half to two inches long: this last change completed, the silk-worm devours its food most voraciously, and increases rapidly during ten days, attaining its full growth, from two and a half to three inches long. When the worm has fixed upon some angle or hollow place whose dimensions agree with the size of the intended silken ball or cocoon, it begins its labour by spinning thin and irregular threads, which are intended to support its future dwelling. During the first day the insect forms upon these a loose structure, of an oval shape, which is called floss-silk: and within which covering, in the three following days, it forms the firm and consistent yellow ball,—the labourer of course, always remaining inside the sphere which it is forming. The silky material, when drawn out, appears to be one thread, but is composed of two fibres, twisted together. The worm, when spinning, rests on its lower extremities throughout the operation, and employs its mouth and front legs in the task of directing and fastening the thread.

At the end of three or four days, the worm will have completed its task, and formed its cocoon. When done spinning, it smears the entire internal surface of the cocoon with a peculiar kind of gum, very similar to the matter that forms the silk, designed to protect the chrysalis from rain and varieties of weather. This gum performs its office so well, that when, for the purpose of reeling the silk with greater facility, the balls are thrown into basins of hot water, they swim on the top of it, with all the buoyancy of bladders, nor does the water penetrate until the silk is nearly all unwound.

The insect now throws off its caterpillar state, and if the cocoon is opened, the inhabitant will appear as a chrysalis, in shape somewhat resembling a kidney-bean, pointed at one end, having a smooth brown skin; its former covering, so dissimilar to the one now assumed, lying beside. The silk-worm remains in the form of a chrysalis, for periods, which, according to the climate or the temperature wherein it may be placed, vary from fifteen to thirty days. It then throws off the shroud which had confined it in its seeming lifelessness, and appears as a large moth, of a grayish white colour, furnished with four wings, two eyes, and two black horns, or antlers. If left until this period within the cocoon, the moth takes immediate measures for its extrication; loosening the gum with which it had lined the interior surface of its dwelling, pushing aside the filaments, and making a passage for itself into light and freedom.

The moth enjoys its liberty for only a very brief space. Its first employment is to seek its mate, after which the female deposits her eggs, producing from 250 to 400, and both, in the course of two or three days, end their being. One hundred cocoons weigh one pound, and 1090 will yield one pound of reeled silk. Each cocoon therefore furnishes nearly eight and a half grains of silk, and the length of its thread is very nearly 1300 yards, or about three quarters of a mile long. A woman experienced in reeling may, with the assistance of a girl to turn the wheel, wind off with ease one pound of raw silk, of the most perfect quality, in one day.

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